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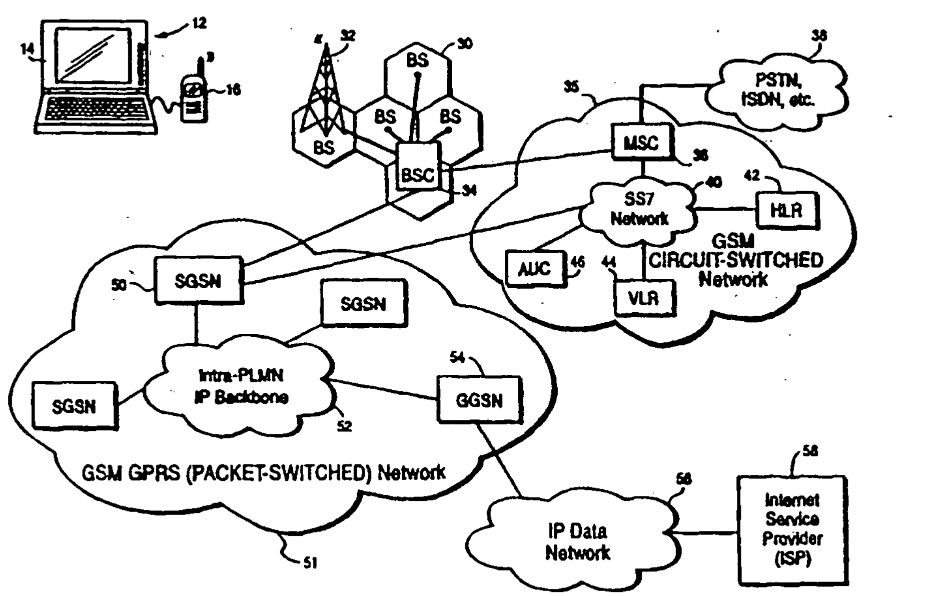
(54) Title: SELECTABLE PACKET-SWITCHED AND CIRCUIT-SWITCHED SERVICES IN A MOBILE COMMUNICATIONS NETWORK

(57) Abstract



Applications running on a mobile station or an external network entity such as an Internet service provider may specify on an individual application flow basis a requested quality of service. From that requested quality of service, an optimal type of bearer to transfer the application flow through the mobile communications network is determined. For example, a circuit-switched bearer may be allocated if the request is for a real-time service, and a packet-switched bearer may be allocated if the request is for a non-real time type of service. Various other decision making criteria may be employed. A mobile station and a mobile network gateway node each include a mapper for mapping an individual application flow to one of a circuit-switched network and a packet-switched network bearers depending on the quality of service requested for the individual application flow. The network layer quality of service parameters corresponding to an individual application flow are mapped to circuit-switched bearer parameters if the application flow is mapped to the circuit-switched network and to packet-switched bearer parameters if the application flow is mapped to the packet-switched network. The gateway node includes a common access server which permits a mobile station initially establishing a communications session with an external network entity to perform only a single, common access procedure for subsequent communications using one of the circuit-switched and packet-switched networks. After that common access procedure is completed, subsequent application flows between the mobile station and the external network entity are established using abbreviated procedures without having to access the external network entity.

SELECTABLE PACKET-SWITCHED AND CIRCUIT-SWITCHED SERVICES IN A MOBILE COMMUNICATIONS NETWORK

RELATED APPLICATION

This application claims priority from U.S. Provisional Patent Application Serial No. 60/060,062 filed September 25, 1997. This application is also related to commonly-assigned U.S. Patent Application Serial No. 09/087,496 filed May 29, 1998, the disclosure of which is incorporated by reference.

FIELD OF THE INVENTION

The present invention relates to mobile communications, and more particularly, to different services and features that may be employed to establish and enhance communications between a mobile station in a mobile communications network and an external network entity.

BACKGROUND AND SUMMARY OF THE INVENTION

The main application of most mobile radio systems like the Global System for Mobile communications (GSM) has been mobile telephony which typically only supports circuit-switched communications where guaranteed, "fixed" circuits are dedicated to a user for the duration of a call. However, packet-switched applications, like facsimile transmission and short message exchange, are becoming popular in mobile networks. Example data applications include wireless personal computers, mobile offices, electronic funds transfer, road transport telemetry, field service businesses, fleet management, etc. These data applications are characterized by "bursty" traffic where a relatively large amount of data is transmitted over a relatively

Conferencing and playback applications, including video and multimedia, are also important services to be supported by mobile networks.

Although circuit-switched services are well known in mobile networks, mobile packet-switched services are quite new. Therefore, a brief description of the latter using GSM/GPRS as an example is now provided.

Fig. 1 shows a mobile data service from a user's point of view in the context of a mobile communications system 10. An end user communicates data packets using a mobile host 12 including for example a laptop computer 14 connected to a mobile terminal 16. The mobile host 12 communicates for example with a fixed computer terminal 18 incorporated in a local area network (LAN) 20 through a mobile packet data support node 22 via one or more routers 24, a packet data network 26, and a router 28 in the local area network 20. Of course, those skilled in the art will appreciate that this drawing is simplified in that the "path" is a logical path rather than an actual physical path or connection. In a connectionless data packet communication between the mobile host 12 and fixed terminal 18, packets are routed from the source to the destination independently and do not necessarily follow the same path (although they can).

Thus, independent packet routing and transfer within the mobile network is supported by a mobile packet data support node 22 which acts as a logical interface or gateway to external packet networks. A subscriber may send and receive data in an end-to-end packet transfer mode without using any circuit-switched mode network resources. Moreover, multiple point-to-point, parallel applications are possible. For example, a mobile host like a mobile PC might run at the same time a video conference application, an e-mail application, a facsimile application, a web browsing application, etc. The video conference application would typically require more than one data stream (hereafter referred to as an application flow).

telephone subscription in the PSTN numbering plan and an international mobile subscriber identity (IMSI) which is a unique identity allocated to each subscriber and used for signaling in the mobile networks. All network-related subscriber information is connected to the IMSI. The HLR 42 also contains a list of services which a mobile subscriber is authorized to use along with a current subscriber location number corresponding to the address of the VLR currently serving the mobile subscriber.

Each BSC 34 also connects to the GSM packet-switched network corresponding to GPRS network 51 at a Serving GPRS Support Node (SGSN) 50 responsible for delivery of packets to the mobile stations within its service area. The gateway GPRS support node (GGSN) 54 acts as a logical interface to external data packet networks such as the IP data network 56. SGSN nodes 50 and GGSN nodes 54 are connected by an intra-PLMN IP backbone 52. Thus, between the SGSN 50 and the GGSN 54, the Internet protocol (IP) is used as the backbone to transfer data packets.

Within the GPRS network 51, packets or protocol data units (PDUs) are encapsulated at an originating GPRS support node and decapsulated at the destination GPRS support node. This encapsulation/decapsulation at the IP level between the SGSN 50 and the GGSN 54 is called "tunneling" in GPRS. The GGSN 54 maintains routing information used to "tunnel" PDUs to the SGSN 50 currently serving the mobile station. A common GPRS Tunnel Protocol (GTP) enables different underlying packet data protocols to be employed even if those protocols are not supported by all of the SGSNs. All GPRS user-related data needed by the SGSN to perform routing and data transfer functions is accessed from the HLR 42 via the SS7 network 40. The HLR 42 stores routing information and maps the IMSI to one or more packet data protocol (PDP) addresses as well as mapping each PDP address to one or more GGSNs.

Before a mobile host can send packet data to an external network like an Internet service provider (ISP) 58 shown in Fig. 2, the mobile host 12 has to (1) "attach" to the GPRS network 51 to make its presence known and (2) create a packet data

Between the SGSN and mobile station/host, a SubNetwork Dependent Convergence Protocol (SNDCP) maps network level protocol characteristics onto the underlying logical link control (LLC) and provides functionalities like multiplexing of network layer messages onto a single virtual logical connection, ciphering, segmentation, and compression. A Base Station System GPRS Protocol (BSSGP) is a flow control protocol, which allows the base station system to start and stop PDUs sent by the SGSN. This ensures that the BSS is not flooded by packets in case the radio link capacity is reduced, e.g., because of fading and other adverse conditions. Routing and quality of service information are also conveyed. Frame relay and ATM may be used to relay frames of PDUs over the physical layer.

Radio communication between the mobile station and the GPRS network covers physical and data link layer functionality. The physical layer is split up into a physical link sublayer (PLL) and a physical RF sublayer (RFL). RFL performs modulation and demodulation of the physical waveforms and specifies carrier frequencies, radio channel structures, and raw channel data rates. PLL provides services for information transfer over the physical radio channel and includes data unit framing, data coding, and detection/correction of physical medium transmission areas. The data link layer is separated into two distinct sublayers. The radio link control/medium access control (RLC/MAC) sublayer arbitrates access to the shared physical radio medium between multiple mobile stations and the GPRS network. RLC/MAC multiplexes data and signaling information, performs contention resolution, quality of service control, and error handling. The logical link control (LLC) layer operates above the MAC layer and provides a logical link between the mobile host and the SGSN.

It is important to be able to provide a certain particular communications service with a requested quality. For example, certain multimedia applications or even a simple voice phone call need guarantees about accuracy, dependability, and speed of

Normally a network technology transfers data only according to one type of transfer mechanism -- either circuit-switched or packet-switched -- even in the GSM which includes both a circuit-switched and a packet-switched network sharing the same radio access interface. In the present invention an optimal type of mobile communications network transfer service -- a circuit-switched transfer service or a packet-switched transfer service -- is specified on an individual application flow basis. Circuit-switched services may be selected, for example, for real time (low delay and small jitter) application flows like audio and video. Packet-switched bearers may be selected for non-real time, Internet type data applications such as surfing on the worldwide web, file transfer, e-mail, and telnet, all of which require fast channel access and bursty data transfer capability.

Initially a mobile station registers with the mobile communications network to establish communication with an external network entity such as an Internet service provider (ISP). During that communication, an application may initiate different data streams or flows of an application (hereafter referred to as application flows) between the mobile station and the external network entity. For each application flow, a determination is made whether a circuit-switched or a packet-switched bearer should be established. A bearer "bears" or carries information from the mobile station through the mobile communications network towards the external network entity and carries information from the external network entity through the mobile communications network to the mobile station.

Each application flow may have a corresponding quality of service request. Based on that corresponding quality of service, a determination is made whether a circuit-switched bearer or a packet-switched bearer is better suited to transport the application flow. The quality of service parameters specified by the application for an individual application flow are mapped to corresponding quality of service parameters for the selected one of the circuit-switched or packet-switched

circuit-switched and packet-switched traffic, e.g., so-called class B GPRS mobile stations.

A significant advantage of the present invention is that applications running on a mobile station or on an external network entity such as an Internet service provider may specify on an individual application flow basis a requested quality of service, and with this information, select the type of bearer to be employed when transferring the application flow through the mobile communications network. Both the quality of service characteristics for an application flow and the type of bearer/transfer mechanism can be selected at the application layer which is advantageous because the application has the best end-to-end perspective of the communication.

The mobile station and a mobile network gateway node each include a mapper for mapping individual application flows to one of the circuit-switched network and the packet-switched network bearers depending on the quality of service requested for an individual application flow. Quality of service parameters corresponding to an individual application flow are also mapped to circuit-switched parameters if the application flow is mapped to the circuit-switched network and to packet-switched parameters if the application flow is mapped to the packet-switched network.

The gateway node includes a common access server which permits a mobile station initially establishing a communications session with an external network entity to perform only a single common access procedure for subsequent communications using either the circuit-switched network or the packet-switched network. After that common access procedure is completed, subsequent application flows between the mobile station and the external network entity are established without having to perform another access procedure involving the external network entity.

The common access procedure includes a common authentication procedure for authenticating the identity of the mobile station with the external network

These onerous delays are eliminated in the present invention. At mobile registration, an initial authentication and configuration procedure using a packet-switched bearer is performed in less than half the 20 to 30 seconds noted above. Even more time is saved because this initial authentication and configuration procedure is not performed for each subsequent individual application flow. Instead, abbreviated authentication and configuration procedures are performed for subsequent flows contained within the mobile communications network at the common access server in just a few seconds.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and other objects, features, and advantages of the invention will be apparent from the following description of preferred embodiments as illustrated in the accompanying drawings in which reference characters refer to the same parts throughout the various views. The drawings are not necessarily to scale with emphasis being placed upon illustrating the principles of the invention.

Fig. 1 is a simplified diagram showing a data communication between a mobile host and a fixed host;

Fig. 2 is a more detailed diagram showing a GSM mobile communications system including a General Packet Radio Service (GPRS) data network;

Fig. 3 illustrates example data communication protocols employed between different nodes in the packet-switched, GPRS data communications network in GSM;

Fig. 4 is a flowchart diagram illustrating optimal bearer selection procedures per application flow in accordance with an example embodiment of the present invention;

DETAILED DESCRIPTION OF THE DRAWINGS

In the following description, for purposes of explanation and not limitation, specific details are set forth, such as particular embodiments, hardware, techniques, etc. in order to provide a thorough understanding of the invention. However, it will be apparent to one skilled in the art that the present invention may be practiced in other embodiments that depart from these specific details. For example, while a specific example embodiment of the present invention is described in the context of a GSM/GPRS cellular telephone network, those skilled in the art will appreciate that the present invention can be implemented in any mobile communications system using other mobile data communications architectures and/or protocols. In other instances, detailed descriptions of well-known methods, interfaces, devices, and signaling techniques are omitted so as not to obscure the description of the present invention with unnecessary detail.

As already described above, each application flow includes a corresponding stream of data. In order for a mobile station to communicate with an external network entity such as an Internet service provider (ISP), the mobile station must establish communications with the mobile communications network by using a dial-out, circuit-switched connection or through an authenticated, packet-switched tunnel. The present invention uses the latter approach to initially establish the application session in order to avoid the setup time required for a dial-out call.

In the GSM/GPRS example, the mobile station initiates a packet data protocol (PDP) context activation to register with the mobile communications system and begin a data session. The HLR 42 in Fig. 2 stores a PDP context for each mobile subscriber in corresponding subscription records. The PDP subscription record includes subscribed quality of service profiles/parameters, subscribed-to external networks, a MSid such as IMSI (International Mobile Subscriber Identity), etc. When a mobile station attaches to the GPRS network, the mobile station's subscription record is

restricting all application flows to a single quality of service and/or a single transfer mechanism. Fig. 4 illustrates an optimal bearer select routine (block 60). Here, it is assumed that the mobile station is already registered with the mobile network using for example the PDP context activation procedures described above (block 61).

After registration, plural application flows are communicated between an external network entity like the Internet service provider (ISP) shown in Fig. 2 and the mobile station. An application (such as a multimedia conference) requests one or more quality of service (QoS) parameters for one or more individual application flows (block 62). Based on the requested quality of service for a specific application flow, an optimal one of a circuit-switched and a packet-switched bearer is selected to carry that specific application flow (block 64). The requested quality of service parameters for each application flow including, e.g., peak bit rate, bucket depth (a maximum buffering requirement for the flow), and per packet delay, are then mapped to bearer parameters of the selected bearer including, e.g., in the case of a packet-switched bearer, peak throughput, burst size, and delay class (block 66). As a result, each application stream receives optimal service in terms of the quality of service parameters as well as the type of transfer mechanism best suited to carry the type of information to be transferred in that specific application flow.

In general, a typical application having plural application flows requiring communication between a mobile station and an external network entity like an ISP may follow the following example procedures:

(1) The mobile station registers using a common access procedure for both circuit-switched and packet-switched bearer communications at the ISP using "low cost" packet-switched bearer and full dynamic host configuration support. Thereafter, only an abbreviated authentication and configuration procedure is required for subsequent absolute application flows as is described in more detail below.

Once the RSVP quality of service request is mapped to a circuit-switched or packet-switched bearer, the quality of service parameters specified for each individual application flow are mapped to circuit-switched or packet-switched parameters depending upon the bearer type selection. In the circuit-switched network, such quality of service parameter mapping involves, for example, selecting an appropriate number of radio channels (e.g., time slots in a TDMA-based system, spreading codes in a CDMA system, etc.), to correspond to the requested bandwidth. In the packet-switched network, there are multiple options to be considered to support quality of service at different protocol layers.

A generalized group of quality of service parameters may be defined for a transfer mechanism and is referred to as a bearer quality of service profile. The bearer quality of service profile may be used to define the quality of service at the radio link control layer, the logical link control layer, and at the GPRS tunneling protocol (GTP) layer in the packet-switched bearer in Fig. 3 to thereby establish an end-to-end quality of service. The radio link control layer is influenced by the packet delay and reliability quality of service parameters of the bearer quality of service profile, while the logical link control layer is also influenced by bit rate and precedence/priority information. The GPRS tunneling protocol between the GPRS serving and gateway nodes SGSN and GGSN must ensure that the tunnel does not violate any of the parameters in the quality of service profile. This requirement is normally met because the radio link is the bottleneck of the mobile communication system architecture.

The corresponding layers in the circuit-switched bearer in Fig. 6 are the radio link protocol and the layer 2 tunneling protocol. The radio link protocol is capable of allocating one or several time slots to a mobile station in order to allocate or change the bandwidth of the circuit-switched connection. The radio link protocol also provides a sub-selection of bearer service type within a range of circuit-switched bearers. The bearer service type may be optimized for voice, video, or data, e.g., V.110

control and relies on transport protocols that handle the resource reservation of the other flows, e.g., RSVP, and the dynamic configuration of the mobile station, e.g., DHCP.

Rather than using a multiplexer, e.g., H.223, which multiplexes all of the four application flow types for transport by one type of bearer, e.g., a circuit-switched bearer like a V.110 modem, the present invention provides a bearer selection and quality of service parameter mapping layer which selects for each application flow at the IP layer the best suited one of a circuit-switched bearer and a packet-switched bearer. In this example depiction in Fig. 7, a circuit-switched bearer is shown as a V.110 modem employing an IP/PPP protocol, and a packet-switched bearer is shown as a GPRS modem employing IP over SNDCP protocol. A circuit-switched modem connection is established by dialing a telephone number to establish a dedicated connection where individual IP packets are not routed. Point-to-point protocol (PPP) is an encapsulation protocol used to carry IP packets over any serial line, dial up connections and therefore is well suited for circuit-switched bearers. Conversely, the GPRS modem routes each IP packet based on its header information. The subnetwork dependence convergence protocol (SNDCP) provides segmentation and compression of headers and data between the mobile station and the SGSN in the GPRS. The SNDCP is specifically developed to carry IP packets directly thereby avoiding PPP.

In a preferred, more specific, but still example embodiment of the present invention, the selection of a particular type of bearer and the mapping of quality of service parameters may be performed in accordance with different prioritized criteria as is now described in conjunction with the Bearer Select and QoS Map routine (block 70) shown in function block format in Fig. 8. Initially, an individual application flow is detected along with a corresponding application flow identifier or an associated quality of service class. In the resource reservation embodiment, an individual application flow may specify and reserve beforehand desired, IP level quality of service parameters. Alternatively, in the differentiated services embodiment, a predefined new service class

below, above, or inside a threshold range. If the bucket depth is present and above the threshold range, the packet-switched bearer functions are selected (block 84). If the bucket depth is below the threshold range, the circuit-switched bearer procedures are selected (block 86). Bucket depth can be analogized to a burstiness quality of the application flow. A very bursty application flow is more suitably carried by a packet-switched bearer. Conversely, an application flow with little or no burstiness (i.e., continuous) is more suited for a circuit-switched bearer.

If the bucket depth parameter is not present for that application flow or is within the threshold range, another decision is made in block 78 whether a service class is specified for this particular application flow. If a best efforts service class is specified, a packet-switched bearer is selected in accordance with the procedures of block 84. If a guaranteed service class is present, the circuit-switched bearer procedures in block 86 are selected. However, if a service class is not specified or a "controlled load" (i.e., somewhere between best efforts and guaranteed type of service) is present, a decision is made in block 80 whether a time-to-live (TTL) parameter is either not present, below, above, or inside a threshold range. If the application has a short time-to-live, a packet-switched bearer is selected in accordance with the procedures in block 84 to eliminate connection setup times associated with a circuit-switched bearer and hopefully communicate the data before its life expires. On the other hand, if the time-to-live parameter is above the threshold range, a circuit-switched bearer is selected in accordance with the procedures outlined in block 86 since the application flow has sufficient life to wait for a circuit-switched bearer to be established.

If the time-to-live parameter is not present or is within the threshold range, a decision is made in block 82 whether the application flow volume (which can be determined by multiplying the time to live parameter by a mean bit rate (MBR)) is not present, below, above, or inside a threshold range. If the flow volume is below the threshold range indicating a fairly small volume, a packet-switched bearer is more

system 100 includes a mobile station 102 that includes a dynamic host configuration protocol (DHCP) client 104, a point-to-point protocol (PPP) client 106, and a bearer selection and quality of service parameter mapper 107. Mobile station 102 is connected (via a circuit-switched and/or packet-switched bearer) over the radio interface to a base station subsystem (BSS) 108. The BSS includes the base station communicating with the mobile station coupled to its base station controller. As is shown in Fig. 2, the base station controller in the BSS 108 routes circuit-switched communications over a circuit-switched bearer to a direct access unit (DAU) 102 in the MSC 110 in the GSM circuit-switched network 35 and packet-switched communications over a packet-switched bearer to the SGSN 114 in the GSM packet-switched (GPRS) network 51. The direct access unit 102 terminates the radio link protocol and the V.110 modem call. As instructed by the HLR conveyed via the MSC, the DAU 102 creates the layer 2 tunnel towards the GGSN. The DAU 102 determines to which specific GGSN to establish the L2TP tunnel using the external entity telephone number and subscription information retrieved from the HLR such as the mobile's IMSI.

For calls originating from the mobile station, the selections of network and network bearer for application flows originating from the mobile station 102 are made by the mobile's mapper 107. Circuit-switched bearers are transferred to an external network gateway node corresponding in the example embodiment to the GGSN 116 using IP/PPP/L2TP protocols. The IP tunnel is created at the V.110 modem connection terminated by the direct access unit. The term "layer 2 tunnel over IP" means that the L2TP protocol, which carries the end-to-end IP traffic, also utilizes an underlying IP network as the transport mechanism between the direct access unit and the GGSN.

The packet-switched application flows are transferred using DHCP/IP/GPRS tunneling protocol. DHCP is only applied at configuration time. Subsequent IP packets (after configuration) are carried directly on the GPRS bearer.

requests from the mobile station for the circuit-switched bearer and uses information from the common access server 118 and the configuration relay agent 120 to answer the requests from the mobile station.

The L2TP server establishes and terminates "virtual calls" over the IP network between the GGSN and the direct access unit 112 in the MSC 110. A virtual call contains the same information and has the same duration as an actual circuit-switched call between the direct access unit 112 and the mobile station. The RTP translator 126 performs a translation of coding schemes between that applied in the high-speed network between the GGSN and the external network entity and a coding scheme more optimally suited to the low-speed radio network in GSM. The RTP translator 126 can be provided with a user profile for each mobile user, e.g., via RADIUS, in order to perform tailored RTP translation for a specific mobile station. The RTP translation functionality increases the likelihood that two entities can communicate with each other.

The mapper 128 performs the link layer selection and QoS mapping functions per individual application flows. More specifically and as described earlier, the mapper 128 decides whether an application reservation request shall be mapped to a circuit-switched or to a packet-switched mobile communications bearer and translates quality of service parameters from an application "view" to a mobile communications bearer "view." However, the mapper may change the link layer bearer selection per packet in certain situations.

One such situation is where a class B mobile has already established a circuit-switched connection and during that circuit-switched connection also receives packet data. As mobile data communications evolve, there will likely be different classes of mobile stations with different capabilities. For example, the GSM currently defines three different classes of mobiles: Class A, class B, and class C. A class A mobile can make and/or receive traffic on both circuit-switched and packet-switched

Both packet-switched and circuit-switched bearer services share the same accounting relationship with the ISP. For example, the RADIUS server maintains a single data record for a mobile station. The data record accumulates accounting information for both types of bearer services keyed to an accounting record identifier corresponding to the mobile's MSid.

Fig. 10 shows example message signaling between various nodes of the communications system shown in Fig. 9 in which an optimal circuit-switched or packet-switched bearer service is selected for different application flows. An ISP relationship is assumed to have already been established between the mobile station and the ISP conference server, and the mobile station has already received some application control packets over a packet-switched bearer. In this example, the ISP conference server 136 now sends IP packets corresponding to a real time application flow from the conference towards the mobile station which are received by the GGSN in the mobile communications system. The GGSN selects the optimal packet-switched or circuit-switched bearer and other parameters such as coding and/or compression rates.

In this example, the RTP translator 126 in the GGSN 116 modifies the coding of the stream from the higher speed conference server 136 to the lower speed mobile communications network based on the mobile station profile and the current RTP coding shown in the packet header. Based on the real-time characteristics of the incoming flow, a circuit-switched bearer is established. The mobile station profile can be administratively configured, set by the authentication (RADIUS) server, or defined by some other user interface. The GGSN uses the mobile station profile in order to select the optimal coding and bearer service for each application flow as explained above in Fig. 8. The GGSN uses the mobile station class along with the bearer service type to switch between packet-switched and circuit-switched bearer services for class B mobiles.

the mobile. Since there is no existing circuit-switched bearer, the GGSN determines that a packet-switched bearer service is more optimal for non-real time type packets and establishes a packet-switched bearer to carry the packets to the mobile station. In particular, a packet switched tunnel is established between the GGSN and the SGSN over the GTP tunnel carrying the IP packets along with a corresponding tunnel identifier (TID). The SGSN then establishes a logical data link (logical link control (LLC)) between the SGSN and the mobile station and forwards the packets on a best efforts basis to the mobile station.

One of the significant advantages of the present invention is that it employs a common access procedure for both circuit-switched and packet-switched bearer services between the mobile station and the Internet service provider. This common access procedure is performed using a "low cost" packet-switched bearer and includes a common authentication procedure and a common configuration procedure. After the common access procedure is completed at initial registration, subsequent application flows are authorized and configured using a very brief procedure that does not require contact with the ISP.

Fig. 11 shows example procedures for a common external network access routine (block 170) in accordance with another aspect of the present invention. When the mobile station establishes a session with the mobile communications network, only a single common access procedure is performed providing the mobile station access to both circuit-switched and packet-switched services (block 172). In particular, only one authentication procedure is performed with one or more authentication parameters, e.g., MSid, Userid, password, etc., resulting from that procedure being stored for subsequent use (block 174). The common access procedure also includes performing only a single ISP-to-mobile station host configuration procedure for both circuit-switched and packet-switched bearer services with the resulting configuration parameters also being stored for subsequent use (block 176).

station's unique identifier (MSid), a user identifier (Userid), a password, and perhaps other parameters that may be used to identify and authenticate the mobile station.

The GGSN maps the DHCP authentication request to a Radius request by selecting a Radius authentication server 132 in the ISP 130 based on the Userid if the Userid has the form of User@ISP. Otherwise, a static mapping of user to ISP is applied in the GGSN. Assuming that the forwarded information is authentic, the Radius server 132 sends an Access Accept message with tunneling configuration information to the common access server in the GGSN. The tunneling configuration information is used by the GGSN to forward common host configuration messages and other IP packets towards the ISP. The GGSN stores the mobile station's MSid (which is based on the mobile's IMSI), Userid, and password and proceeds with the common host configuration procedure explained in more detail below. At this point, the common authentication procedure with the ISP is completed for both circuit-switched and packet-switched bearer services.

Still referring to Fig. 12, assume that a new application flow is started at the mobile station (e.g., an audio call from the mobile (party A) to a called party B) for which a circuit-switched bearer is selected. The direct access unit 112 in the MSC 110 terminates the modem connection corresponding to the circuit-switched bearer selected for that new application flow. The direct access unit 112 analyzes the B telephone number of the called party, and selects an L2TP endpoint based on that B number and HLR subscription data, i.e., the appropriate GGSN for connecting the call to B. The direct access unit 112 then sends an authentication request to the common access server at the selected GGSN, shown in the Fig. 12 example in the form of a password authentication protocol (PAP) or challenge authentication protocol (CHAP) request, to forward the mobile station's authentication parameters including the MSid, Userid, and password to the common access server.

mobile station is not "faking" its identity during the dynamic host configuration procedures. Accordingly, following the above-described common authentication procedure, the configuration relay agent 120 adds the GGSN's IP address to the giaddr field and relays the DHCP Discover message to the DHCP server.

The DHCP server 134 in the ISP replies to the Discover message with an Offer message passed on by the GGSN relay agent 120 towards the mobile station including the "offered" configurations that the DHCP server 134 can provide (after checking the incoming and outgoing tunnel identifiers). Multiple offers can be received from various DHCP servers. The mobile station selects the DHCP offer that best satisfies its requirements and sends a DHCP request message to the DHCP server which provided the selected offer. The DCHP server then provides an IP address to the GGSN in a DHCP Acknowledgment message. The IP address is placed in a table along with the mobile's agent remote ID and agent circuit ID/tunnel identifier.

The DHCP Acknowledge message is relayed to the mobile host which is configured with a set of selected DHCP parameters including IP address, DNS server name, etc. The common access server in the GGSN also stores these configuration parameters like the IP address allocated to the mobile station along with the authentication parameters like the MSid, Userid, password, etc.

Because the circuit-switched and packet-switched bearer services share the same IP termination/IP address in the mobile station, the common IP host configuration made over the packet-switched (GPRS) bearer service covers subsequent circuit-switched PPP sessions from the same mobile station using the circuit-switched bearer service. If the mobile station initiates a new application flow over a circuit-switched bearer, i.e., in the example shown in Fig. 13 by sending a PPP Configure-Request via an L2TP tunnel to the GGSN, the common access server compares the PPP Configure Request parameters including an MSid and default configuration parameters with the stored DHCP configuration information and returns an Acknowledgment if the

full and enabling disclosure of the invention. Accordingly, it is intended that the invention be limited only by the spirit and scope of the claims appended hereto.

5. The method in claim 4, wherein the indicator is the same for all packets in an application flow when resources are reserved for the application flow.

6. The method in claim 4, wherein the indicator is a class indicator based on one of plural service classes with all packets of the same service class being carried on the type of bearer determined by the class indicator.

7. The method in claim 1, further comprising:

establishing an accounting record that stores accounting information for both circuit-switched and packet-switched bearer services provided to a mobile station.

8. The method in claim 1, further comprising:

for each of the plural application flows, determining whether the application flow requests a real time type of service or a non-real time service,

allocating a circuit-switched bearer if the request is for a real time type of service and a packet-switched bearer if the request is for a non-real time type of service.

9. The method in claim 8, further comprising:

allocating a packet-switched bearer to carry an application flow containing session control operation information.

10. The method in claim 8, wherein real time services include one or both of audio and video services and non-real time services include one or more of file transfer, e-mail, retrieval of information from the world wide web, and telemetry applications.

11. The method in claim 1, further comprising:

allocating a circuit-switched bearer if the application flow requests low delay or small jitter and a packet-switched bearer if the application flow requests fast channel access or bursty data transfer capability.

16. The method in claim 15, wherein the application determines whether a circuit-switched or a packet-switched bearer should be selected for each application flow and requests the selected bearer from the IP link layer service.

17. The method in claim 16, wherein the IP link layer service is provided in the mobile station and at a mobile network gateway node that interfaces with the ISP.

18. The method in claim 1, wherein the mobile station monitors channels for both circuit-switched and packet-switched services.

19. The method in claim 18, wherein the mobile station operates on only one or both of the circuit-switched and packet-switched services at one time.

20. In a mobile communications system including a circuit-switched mobile network and packet-switched mobile network, a method comprising:

the mobile station establishing a communication session with the mobile communications network during which plural flows of an application are communicated between the mobile station and an external network entity, each application flow having a corresponding quality of service request, and

mapping individual ones of the application flows to one of the circuit-switched network and the packet-switched network depending on the quality of service corresponding to each of the individual application flows.

21. The method in claim 20, the mapping step further comprising:

allocating a circuit-switched network link to the application flow if the circuit-switched network is selected, and

allocating a packet-switched network link to the application flow if the packet-switched network is selected.

22. The method in claim 20, further comprising:

mapping quality of service parameters requested for a corresponding individual application flow into circuit-switched parameters if the application flow is mapped to

27. The method in claim 25, wherein for the subsequent application flows, only an abbreviated authentication procedure is performed in the mobile network.

28. The method in claim 24, wherein the common access procedure includes a common configuration procedure for configuring the mobile station with the external network entity whereafter the mobile station is configured with a common network address for subsequent ones of the plural application flows with the external network entity through both of the circuit-switched and packet-switched networks.

29. The method in claim 28, wherein the common configuration procedure includes:

providing the mobile station with parameters needed to communicate with the external network entity including a network layer address assigned to the mobile station by the external network entity, and

storing the parameters in the mobile communications network,

wherein for subsequent application streams involving the mobile station during the session, the method further comprises:

retrieving the stored parameters to configure the subsequent application stream without involving the external network entity.

30. The method in claim 24, wherein the mobile communications system includes a gateway node for interfacing with the external network entity, the method further comprising:

registering the mobile station with the gateway node, and

the mobile station requesting an end-to-end configuration between the mobile station and the external network entity,

wherein the end-to-end configuration request establishes a network layer bearer between the mobile host and the gateway node permitting relay of data packets between the external network entity and the mobile host even though a network layer address is not assigned to the mobile host.

36. The method in claim 35, further comprising:

storing one or more parameters resulting from the common authentication procedure in a node in the mobile communication system, and

for the subsequent application flow, comparing the stored one or more parameters with an authentication request associated with the subsequent application flow,

wherein if the comparison results in a match, the subsequent application flow is authenticated.

37. In a mobile communications system including a circuit-switched mobile network and packet-switched mobile network, a method comprising:

the mobile station initiating establishment of a communication session with the mobile communications network during which plural flows of an application are communicated between the mobile station and an external network entity, and

performing a common configuration procedure of the mobile station with the external network entity for both the circuit-switched and packet-switched networks to configure the mobile station for communication with the external network entity,

wherein after the common configuration procedure, a subsequent application flow is established with the external network entity without performing another configuration procedure involving the external network entity.

38. The method in claim 37, further comprising:

storing one or more parameters resulting from the common configuration procedure in a node in the mobile communications system, and

for the subsequent application flow, comparing the stored one or more parameters with a configuration request associated with the subsequent application flow,

wherein if the comparison results in a match, the subsequent application flow is configured.

44. The mobile communications system in claim 40, further comprising:

a circuit-switched network including a direct access unit where a circuit-switched link is established between the mobile station and the direct access unit for each application flow that is assigned a circuit-switched bearer, and

a packet-switched network including a serving node where a packet-switched link is established between the mobile station and the serving node for each application flow that is assigned a packet-switched bearer.

45. The mobile communications system in claim 44, wherein a circuit-switched tunnel is established between the direct access unit and the gateway node and a packet-switched tunnel is established between the serving node and the gateway node.

46. The mobile communications system in claim 45, wherein the mobile communications system is the GSM, the direct access unit is provided in a mobile switching center, the packet-switched network is the GPRS network, the serving node is a serving support GPRS node (SSGN), the gateway node is a gateway GPRS support node (GGSN), the circuit-switched link is a radio link protocol connection, the packet-switched link is a link layer connection, the tunnel between the SSGN and the GGSN employs GPRS tunneling protocol (GTP), and the tunnel between the direct access unit and the GGSN is a layer two tunneling protocol (L2TP).

47. The mobile communications system in claim 40, wherein the mobile station is a class B mobile station that supports simultaneous registration with the circuit-switched and packet-switched services networks but does not support simultaneous circuit-switched and packet-switched traffic, and

wherein when a circuit-switched bearer is established for an application flow, packet-switched data are transmitted over the established circuit-switched bearer.

48. The mobile communications system in claim 47, wherein when the circuit-switched bearer is released, packet-switched data are transmitted to the class B mobile station over a packet-switched bearer.

55. The mobile communications system in claim 54, wherein if the common access server determines that a mobile identifier and password received from the mobile station associated with a subsequent application flow match the stored information, the subsequent application flow is authorized without involving the external network entity.

56. The mobile communications system in claim 50, wherein the common access procedure includes a common configuration procedure for configuring the mobile station with the external network entity such that the mobile station is configured for subsequent application flows with the external network entity for both circuit-switched and packet-switched services.

57. The mobile communications system in claim 56, wherein in the common configuration procedure the common access server provides the mobile station with one or more parameters needed to communicate with the external network entity including a network layer address, stores the one or more parameters, and for subsequent application streams involving the mobile station during the session, retrieves the stored parameters to configure the subsequent application without involving the external network entity.

58. The mobile communications system in claim 57, wherein the common access server functions as a dynamic configuration relay agent between the mobile station and the external network entity.

59. For use in a mobile communications system including a circuit-switched network and a packet-switched network connected to an external network entity, a mobile terminal comprising:

an application with plural application flows, each application flow associated with a corresponding quality of service, and

a mapper mapping ones of the application flows to one of a circuit-switched bearer and a packet-switched bearer depending on a type of service associated with each of those application flows.

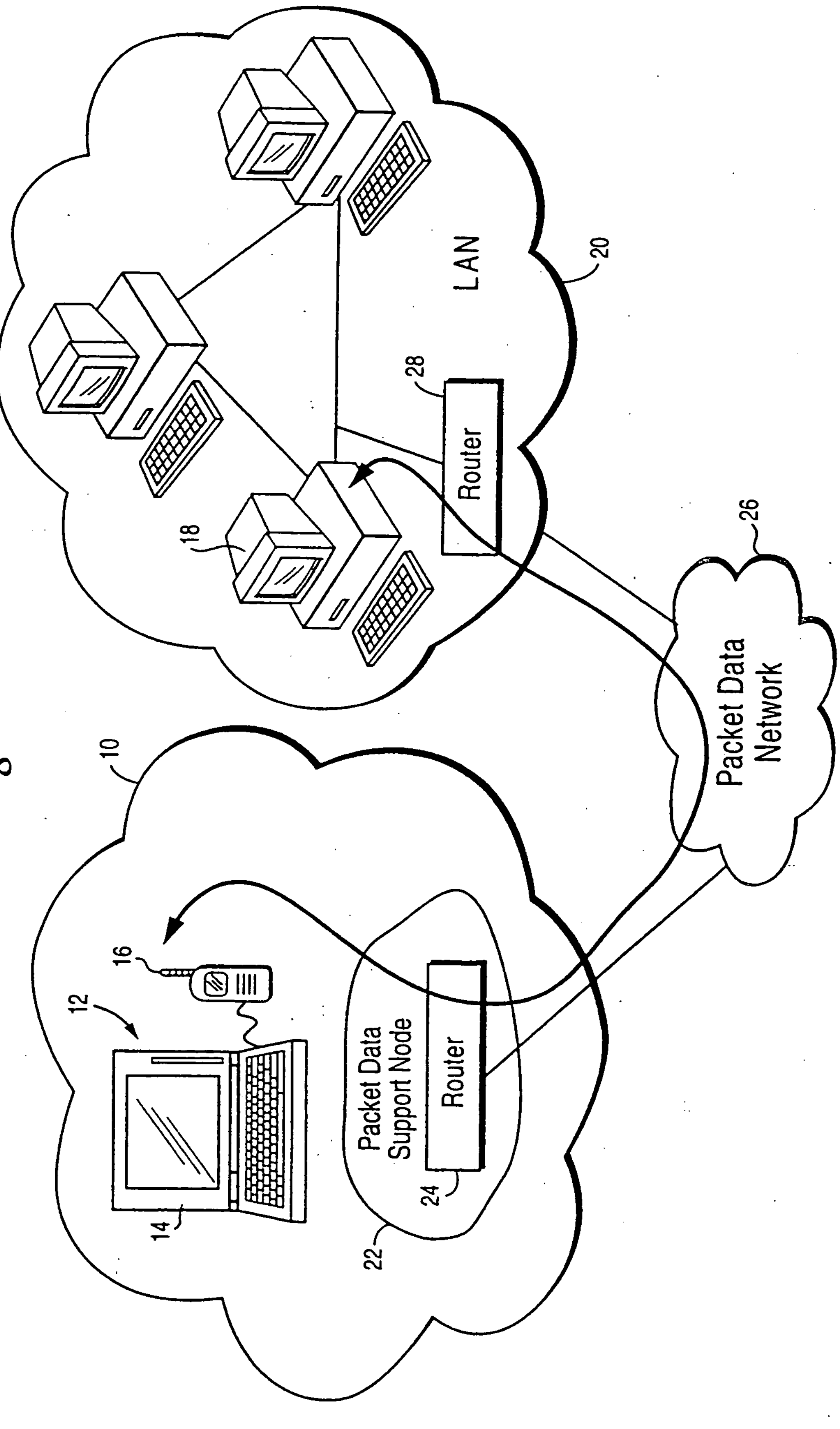

LAN
20
28
Router
18
26
Packet Data Network
10
12
16
14
Packet Data Support Node
Router
24
22

Fig. 1

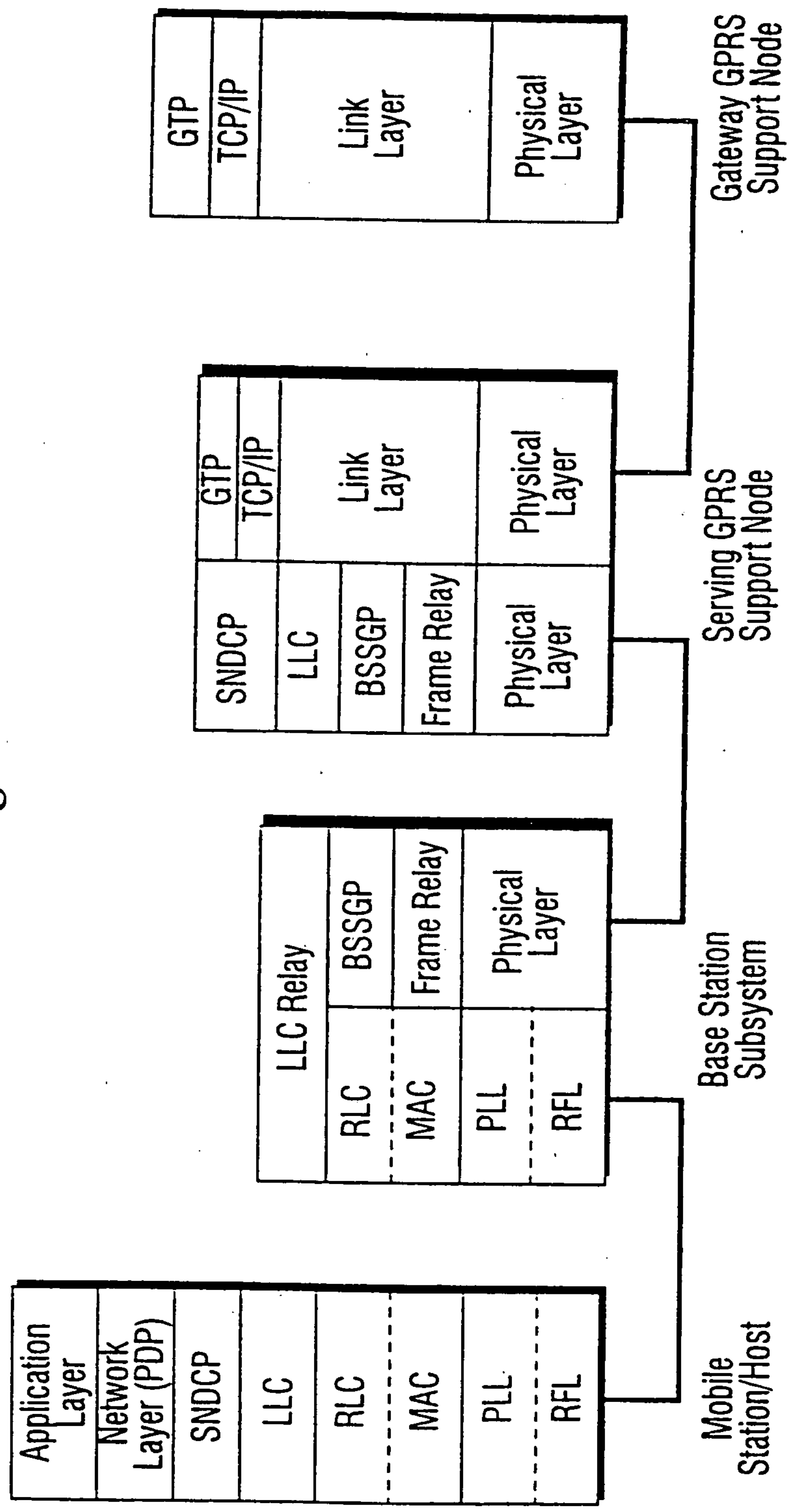

GTP
TCP/IP
Link Layer
Physical Layer
Gateway GPRS Support Node
SNDCP
LLC
BSSGP
Frame Relay
Physical Layer
GTP
TCP/IP
Link Layer
Physical Layer
Serving GPRS Support Node
LLC Relay
RLC
MAC
PLL
RFL
BSSGP
Frame Relay
Physical Layer
Base Station Subsystem
Application Layer
Network Layer (PDP)
SNDCP
LLC
RLC
MAC
PLL
RFL
Mobile Station/Host

Fig. 3

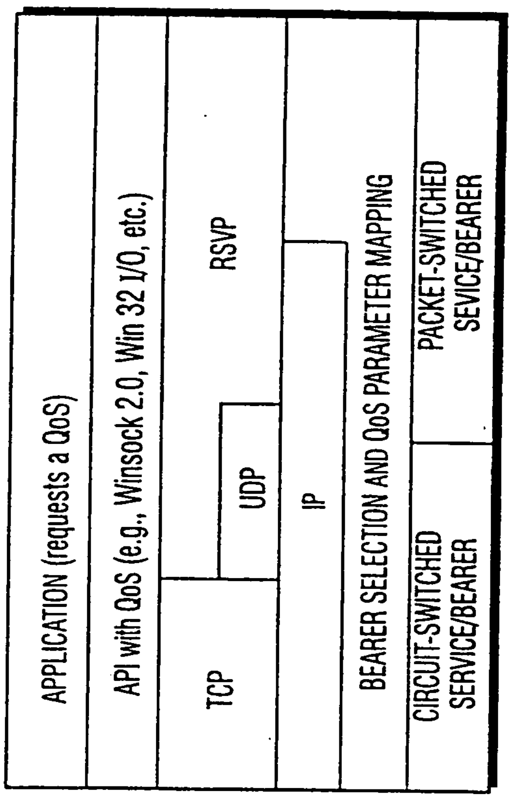

APPLICATION (requests a QoS)
API with QoS (e.g., Winsock 2.0, Win 32 I/O, etc.)
TCP
UDP
RSVP
IP
BEARER SELECTION AND QoS PARAMETER MAPPING
CIRCUIT-SWITCHED SERVICE/BEARER
PACKET-SWITCHED SEVICE/BEARER

Fig. 5

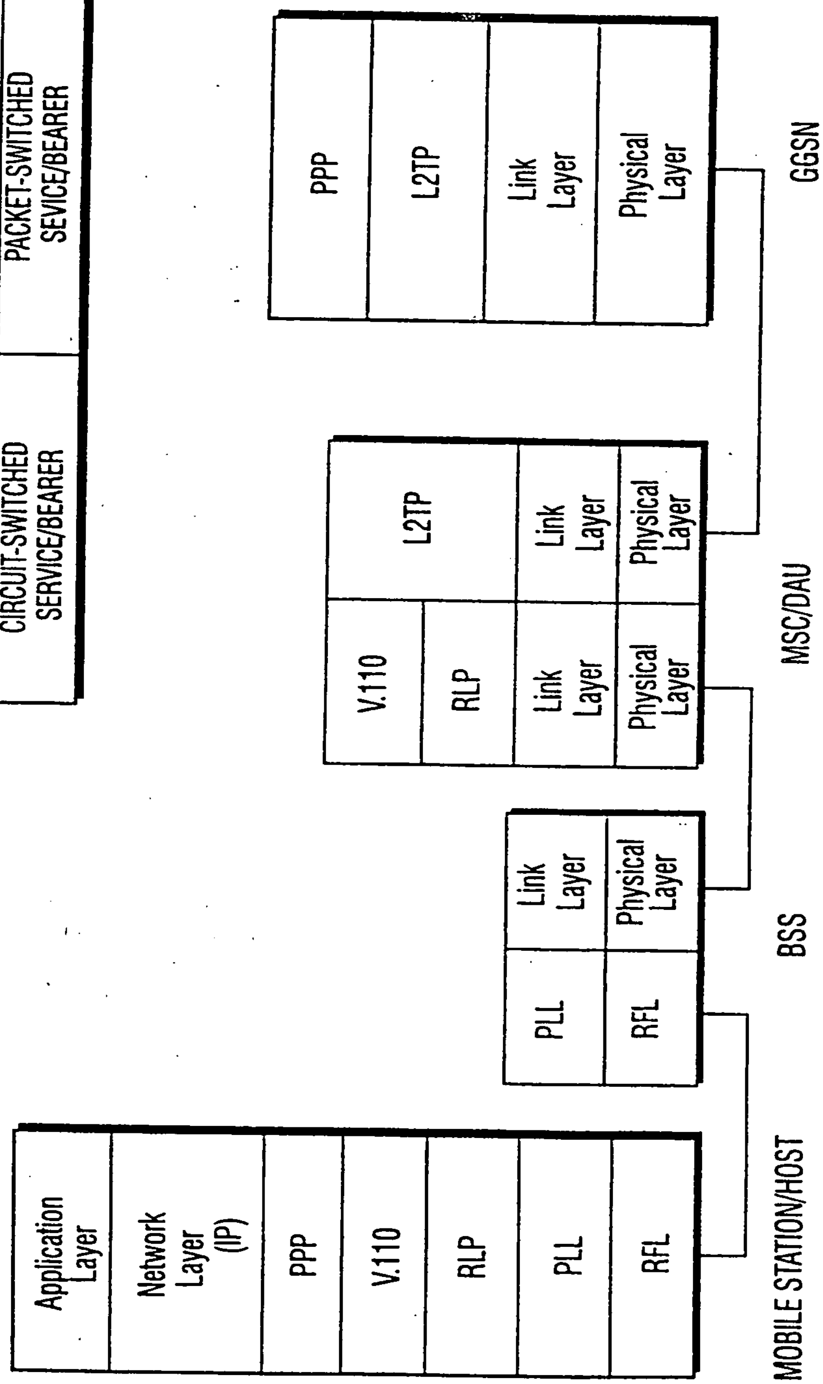

Application Layer
Network Layer (IP)
PPP
V.110
RLP
PLL
RFL
MOBILE STATION/HOST
PLL
RFL
Link Layer
Physical Layer
BSS
V.110
RLP
Link Layer
Physical Layer
L2TP
Link Layer
Physical Layer
MSC/DAU
PPP
L2TP
Link Layer
Physical Layer
GGSN

Fig. 6

Fig. 8

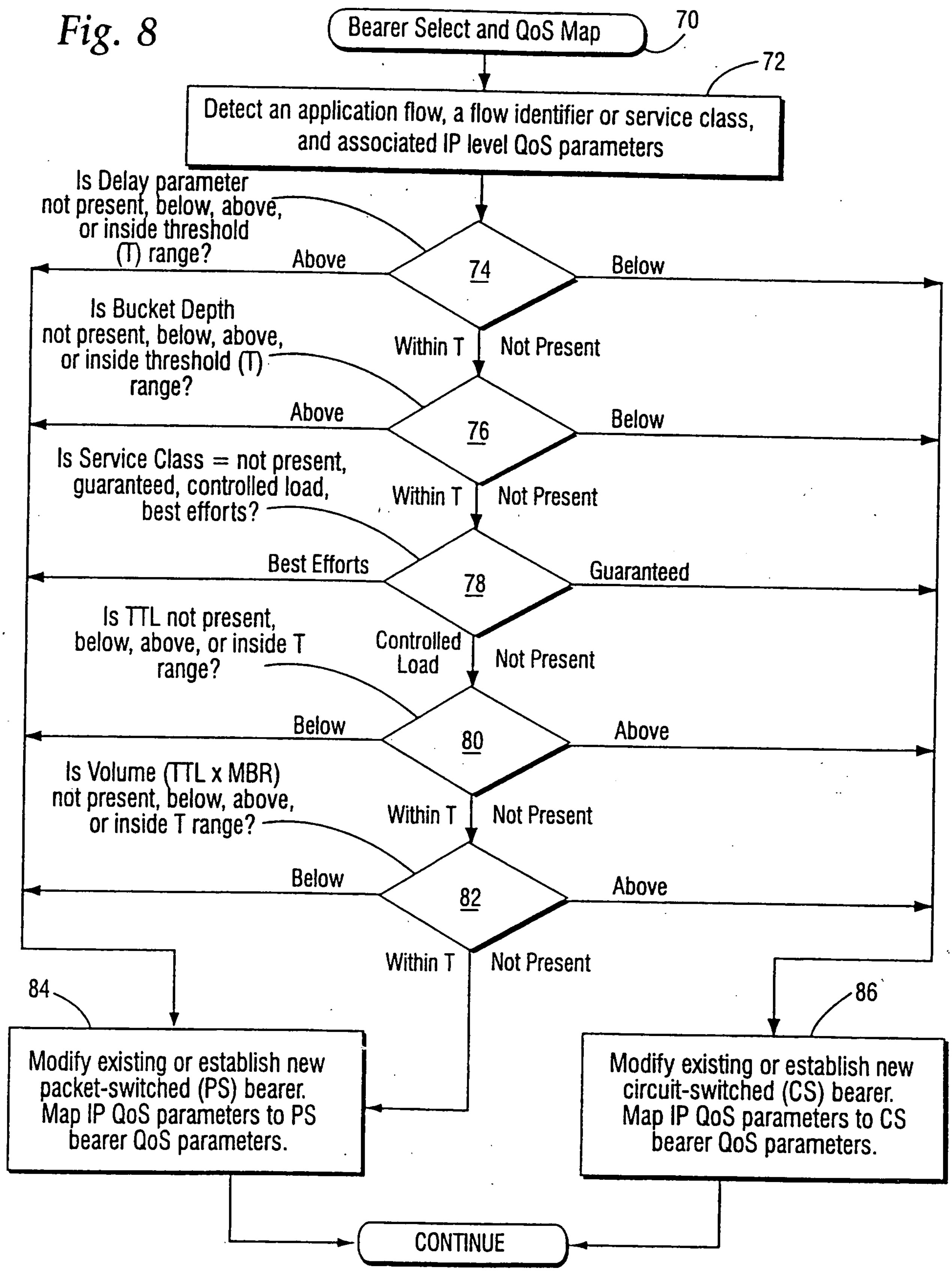
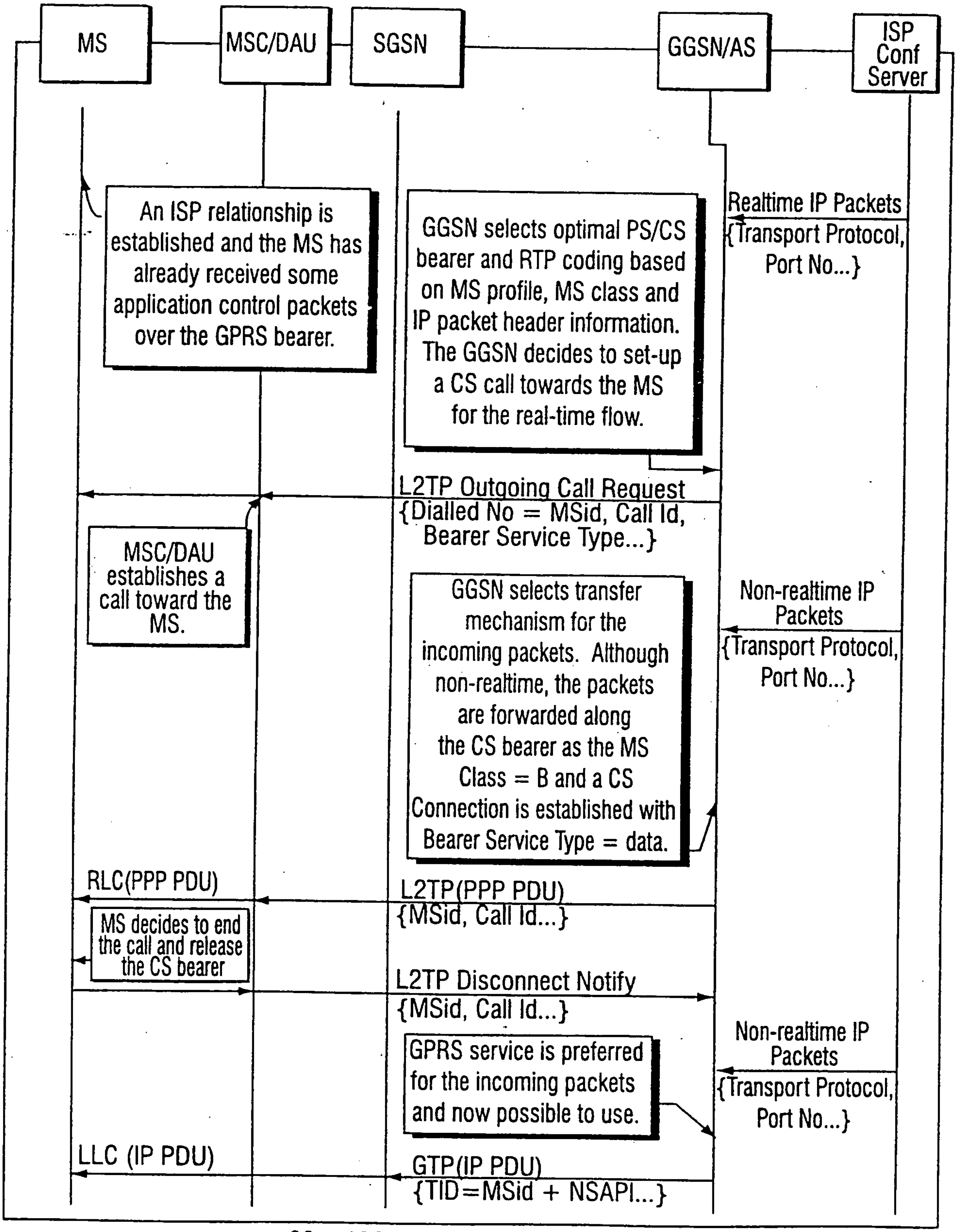
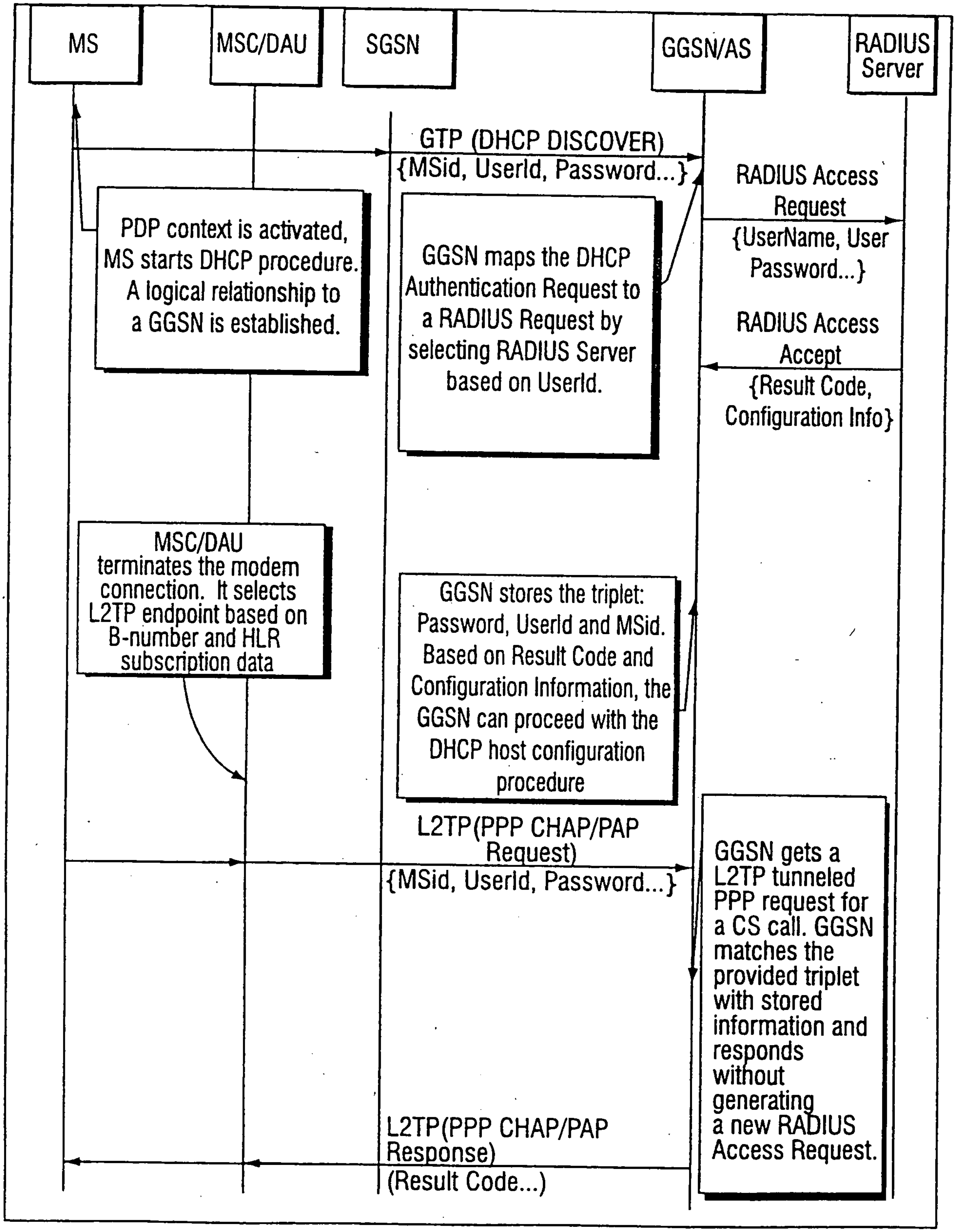

Bearer Select and QoS Map
70
72
Detect an application flow, a flow identifier or service class, and associated IP level QoS parameters
Is Delay parameter not present, below, above, or inside threshold (T) range?
Above
74
Below
Within T
Not Present
Is Bucket Depth not present, below, above, or inside threshold (T) range?
Above
76
Below
Within T
Not Present
Is Service Class = not present, guaranteed, controlled load, best efforts?
Best Efforts
78
Guaranteed
Controlled Load
Not Present
Is TTL not present, below, above, or inside T range?
Below
80
Above
Within T
Not Present
Is Volume (TTL x MBR) not present, below, above, or inside T range?
Below
82
Above
Within T
Not Present
84
86
Modify existing or establish new packet-switched (PS) bearer. Map IP QoS parameters to PS bearer QoS parameters.
Modify existing or establish new circuit-switched (CS) bearer. Map IP QoS parameters to CS bearer QoS parameters.
CONTINUE

Fig. 10



CS and PS Bearer Service Selection

Fig. 12



MS-ISP Authentication for CS and PS Services

INTERNATIONAL SEARCH REPORT

International Application No
PCT/SE 98/01649

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H04Q7/22 H04L12/56

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H04Q H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 96 09708 A (NOKIA MOBILE PHONES LTD ;HAEMAELAEINEN JARI (FI); JORMALAINEN JANN) 28 March 1996 see page 4, line 11 - page 9, line 25 ---	1,8-10, 18-21, 23,24,59
A	WO 95 25407 A (SIERRA WIRELESS INC ;TOMS NORMAN (CA)) 21 September 1995 see page 3, line 18 - page 8, line 22 ---	1,18-21, 59
A	EP 0 789 499 A (TELIA AB) 13 August 1997 see column 2, line 17 - column 4, line 7 -----	24-29, 35-38,40

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
10 December 1998	17/12/1998

Name and mailing address of the ISA	Authorized officer
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